SENSITIVE RESEARCH INSTRUMENT CORPORATION

Electrical Instruments of Precision

Electrical Instrument Engineers Since 1919

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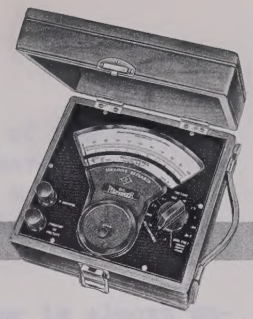

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OPERATING INSTRUCTIONS FOR ELECTROSTATIC VOLTMETERS

MODELS ESH - ESD & UNIVERSITY

DESCRIPTION OF ELECTROSTATIC VOLTMETER

SENSITIVE RESEARCH Electrostatic Voltmeters are double pivoted, rugged, fast reading instruments, which derive their torque from the attraction of charged metallic surfaces. The use of modern insulating material permits us to make the insulation resistance as high in some cases as 5×10^{15} OHMS thereby making the leakage current of these instruments virtually negligible.

The first consideration in understanding these instruments is the fundamental one, that they are VOLTAGE OPERATED. This distinguishes them from ALL other types which are CURRENT OPERATED. In some cases they do draw current, sometimes even an appreciable amount, but it is incidental to the operation and is NOT the cause of the deflection. Their deflection is directly proportional to the RMS value of the voltage appearing between the plates---and to nothing else.

On D.C. the instrument draws a momentary charging current which almost instantly drops to a negligible value determined by the insulation resistance of the instrument. The insulation resistance will vary only slightly with environmental (humidity, temperature, etc.) conditions. However, under the worst conditions the current drawn by the instrument from this cause is several hundred times smaller than the current of any other type of voltmeter. The charging current is almost always a negligible quantity. Its exact value, of course, is determined mainly by the inductance and resistance of the external circuits. In most cases the electrostatic voltmeter can be safely considered a ZERO CURRENT device.

It should be understood by the user of the electrostatic voltmeter that the instrument measures RMS VOLTAGE. This is true

whether the voltage is D.C., sinusoidal A.C., or of the pulse type. The pulse or high peaked type of voltage wave usually has an RMS value which is small compared to the peak value. This sometimes misleads the user into thinking that the instrument is not functioning properly.

The frequency range of the electrostatic voltmeter is almost unlimited. There are two phenomena which place the upper frequency limit on its use. The electrostatic voltmeter as a circuit element is a very low loss capacitor. Its capacitance lies between the limits of 225 mmf. for the 120 volt instruments to about 10 mmf. for the 100 kv. In the radio frequency range the reactance of the instrument is a quality also to be considered. The second limitation is that of the instrument and its leads behaving like a resonant or partially resonant transmission line. The leads and the capacitive termination formed by the voltmeter movement may result in a voltage distribution along the line which is not constant. Thus, the instrument may indicate a voltage which is not the same as that to which the leads are connected.

From Coulomb's law, and more analysis, we know that the instantaneous torque developed by the electrostatic voltmeter, is equal to a constant (for a given deflection) times the square of the instantaneous terminal voltage. If the instantaneous terminal voltage is steady D.C., then the average torque, which produces the deflection, is the same as the instantaneous torque and the instrument reads D.C. voltage. In addition to the instrument reading D.C. voltage, let us examine what happens when alternating voltages are applied to the electrostatic voltmeter. As stated above, the instantaneous torque of the electrostatic voltmeter is proportional to the square of the instantaneous terminal voltage. This results in the alternating voltage producing surges of torque which are mechanically averaged by the instrument movement. The instrument movement can do an accurate averaging job because it has a mechanical time constant which is very long, compared to the period of the alternating voltage being measured. Consequently, the instrument responds to the theoretical concept of the root mean square voltage, regardless of wave shape.

Due to contact potentials which unavoidably exist between the dissimilar metals which are used in the construction of high sensitivity electrostatic voltmeters, there is a certain very small reversal effect on direct current. The voltmeter will read slightly higher when connected in one polarity than when connected with the other. The alternating current will read between the two direct current readings. The magnitude of the potential is such that the reversal error is approximately $\pm$ 1 volt any place on the instrument scale. Instruments with a range of 500 volts or higher have a negligible A.C. and D.C. difference.

Electrostatic instruments have an inherent limitation in frequency based on the current carrying capacity of the instrument. For any given combination of voltage and frequency the capacity of the instrument will allow a current to flow. This current must not exceed 200 ma. (for all models), or a permanent change in calibration may occur. This gives an upper frequency limit which is

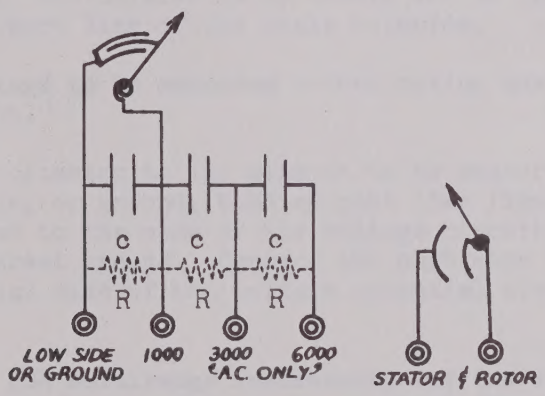
dependent on the voltage at which the instrument is used.

For example: A 30 Kv. instrument (capacity about 10 mmf.) used at 20 Kv. could be used up to approximately 160 Kc.

MODEL ESH (SWITCH SELECTED RANGES)

The question naturally arises as to how we can obtain multirange electrostatic voltmeters. Since sensitivity of an electrostatic voltmeter depends upon the spacing of the electrodes, we can vary the sensitivity by varying the electrode spacing. The SENSITIVE RESEARCH Model ESH high voltage electrostatic voltmeter uses this principle in a very refined mechanism for positioning the stationary electrode in as many as four positions to obtain up to four full scale ranges of voltage in one instrument. It also has the advantage of the capacity of the voltmeter becoming LOWER as the voltage ranges are increased.

MULTIRANGE (MODEL ESD & UNIVERSITY)



The Model ESD and University Model electrostatic voltmeters obtain their multiranges by different means. It is not convenient to vary the spacing of the electrodes in the more sensitive instruments and so capacity type voltage multipliers are used. From the circuit shown above it will be seen that the condensers "C" will form a voltage divider for AC components which will provide accurately fixed multiplying factors. The resistances shown as "R" in dotted lines are the upsetting factor when DC is applied. These represent the leakage resistances of the individual condensers used in the divider. Due to normal manufacturing tolerances this leakage resistance can only be held ABOVE SOME GIVEN HIGH VALUE, but NOT TO A DEFINITE VALUE OF RESISTANCE.

The D.C. path is through these various leakage resistances and the voltage appearing across the movement is proportional to these uncertain leakages, and hence, of a very variable value.

Because of the uncertainty of the leakages, multirange Model ESD and University Model instruments should be used for DC readings ONLY ON THE LOWEST RANGE.

Since the electrostatic voltmeter as a circuit element is a high quality capacitor, the power taken by the instrument is negligible. Of course, in exchange for this extremely high power sensitivity, the electrostatic voltmeter requires that the necessary charge be supplied from the circuit under measurement, whether the measurement is alternating current or direct current. On direct current, only the initial charging current is required, whereas on alternating current, a capacitive alternating current flows just as in any capacitor. The capacitive current is negligibly small at power or audio frequencies, and there are many electrostatic voltmeters in use even at radio frequencies.

OPERATIONAL PROCEDURE (ALL MODELS)

A. Place the instrument on an approximately level surface. For best accuracy do not use at any angle of more than 5 degrees from the horizontal in any direction.

B. Set the pointer on zero by rotating by hand the zero shifter on the top of case. The pointer is correctly set on zero when the pointer and the zero line of its scale coincide.

C. Turn off voltage to be measured before making any connections to the instrument.

D. Connect the voltmeter to the circuit to be measured, making sure that the low side, or ground, binding post (See figures 1 or 1A or 1B) are connected to the side of the voltage circuit that will be at ground or nearest ground. Connect the high side binding post to the high potential side of the voltage potential circuit to be measured.

E. On the Model ESH Multirange instrument, set the voltage range selector slide rod (figure #2) to the position (See instruction plate on rear of instrument case) required for the voltage to be measured. If in doubt as to value of voltage, start measurements with slide all the way out, which is the highest range. Apply voltage and wait for the pointer to come to rest. If the high range does not produce an easily read deflection, TURN VOLTAGE OFF then push slide in to the next "click" position. Repeat the above applying voltage again. Be sure that the "Click Position" is positively restraining the slide in a definite position.

F. Read the voltage. Please note that there is a separate hand drawn scale for each range in volts. Be sure that you are reading the correct scale.

CAUTION

The binding post marked "low side or ground" must be used at or near ground potential for safety reasons. The leakage resistance between the "low" terminal and case fittings and panel screws is NOT comparable with the insulation between terminals. If operation off ground is required, instrument should not be touched during operation.

MODEL ESD & UNIVERSITY CONNECTIONS

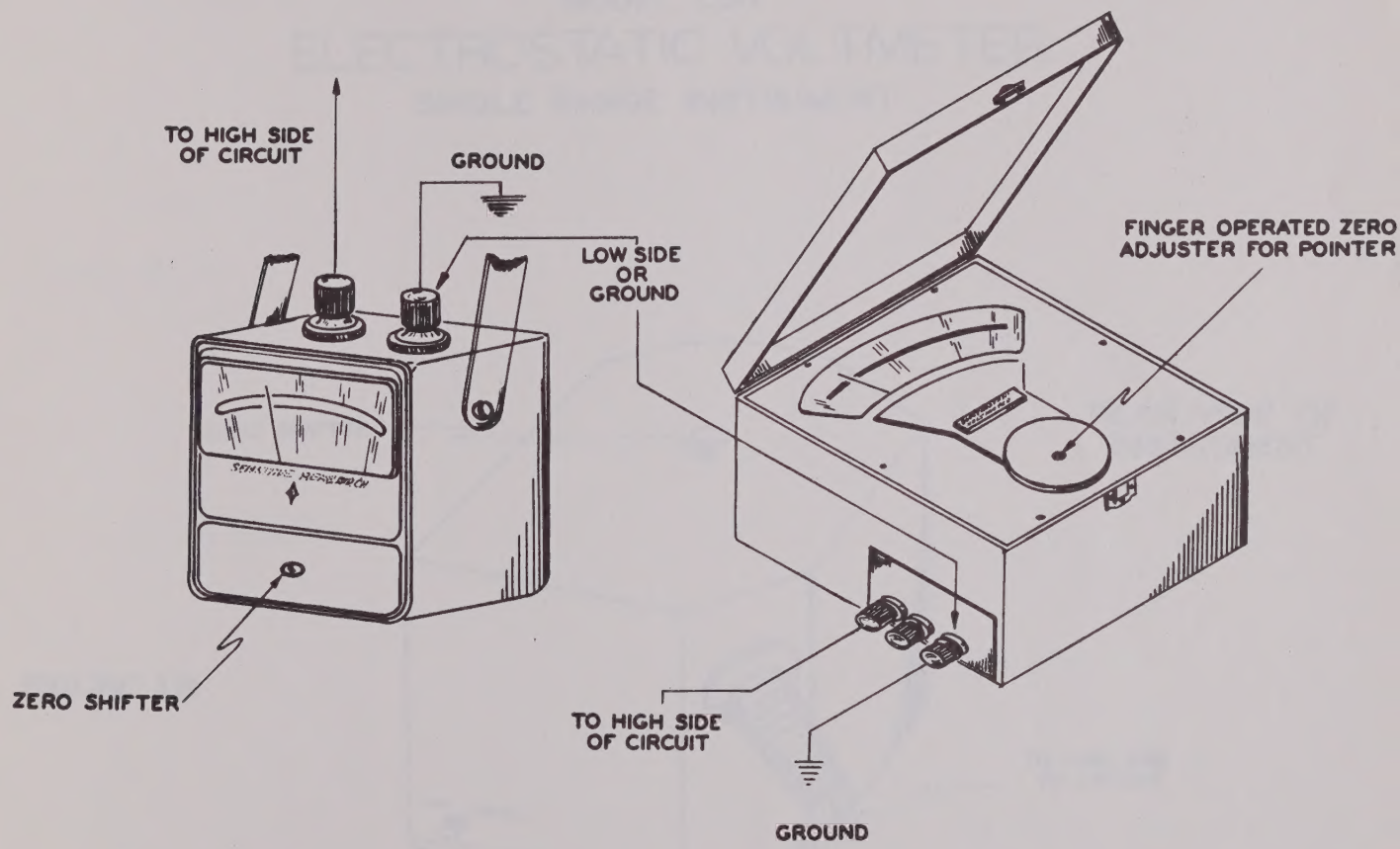
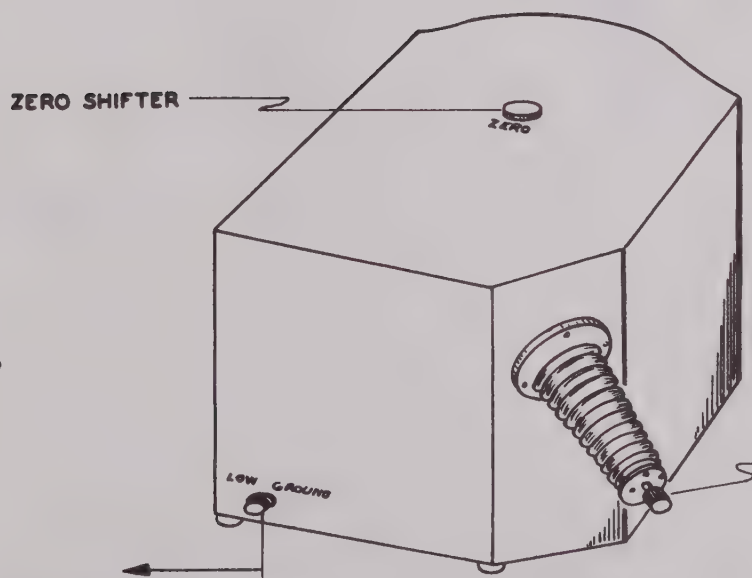


FIGURE 1

MODEL ESH

ELECTROSTATIC VOLTMETER

SINGLE RANGE INSTRUMENT



REAR VIEW OF INSTRUMENT

FIGURE 1B

CONNECTIONS OF SINGLE RANGE INSTRUMENTS FROM 5000 VOLTS TO 60000 VOLTS

MODEL ESH
ELECTROSTATIC VOLTMETER
MULTIRANGE INSTRUMENT

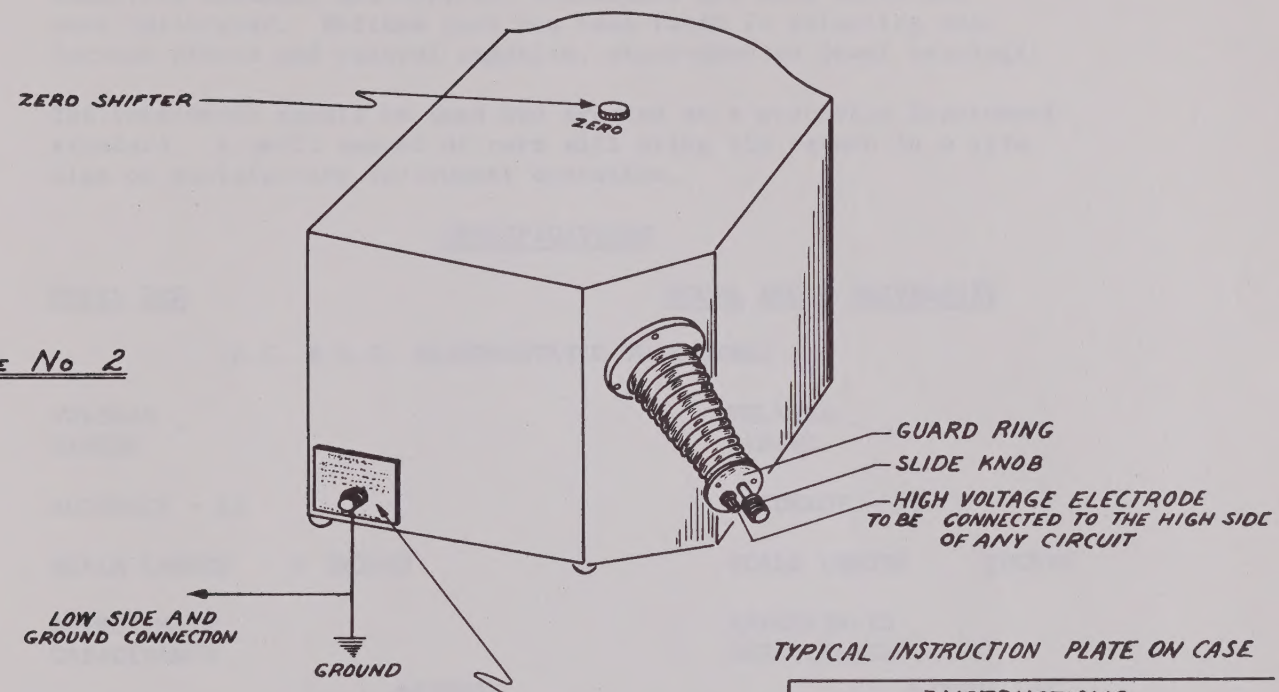
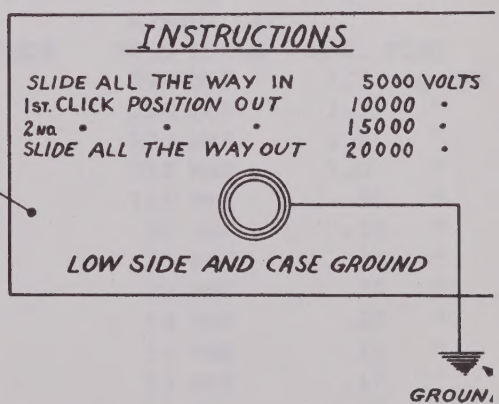


FIGURE No 2

TYPICAL INSTRUCTION PLATE ON CASE


INSTRUCTIONS
SLIDE ALL THE WAY IN 5000 VOLTS
1st. CLICK POSITION OUT 10000 •
2nd. • • • 15000 •
SLIDE ALL THE WAY OUT 20000 •
LOW SIDE AND CASE GROUND
GROUN

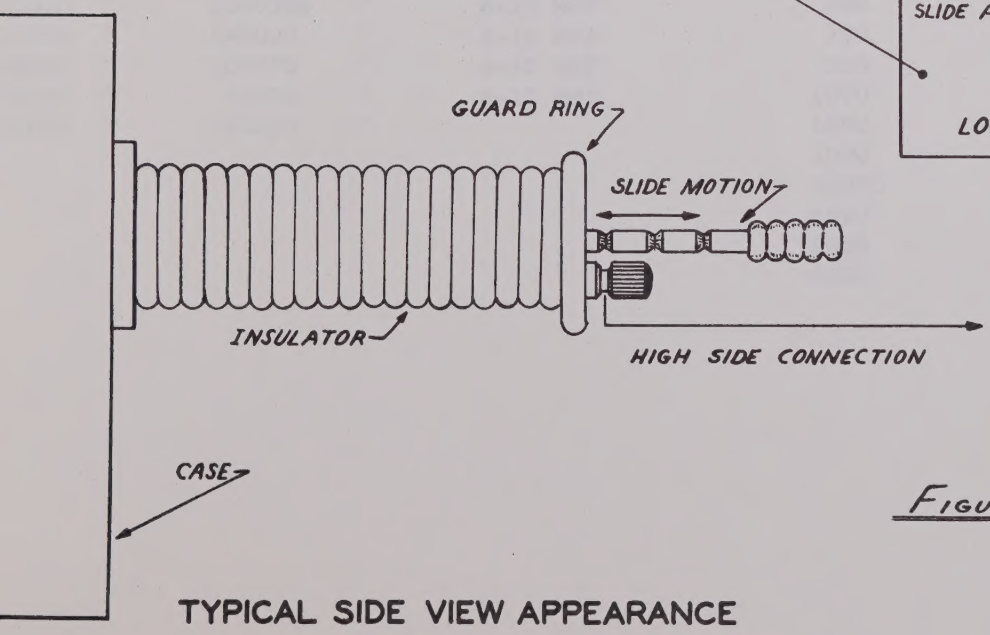
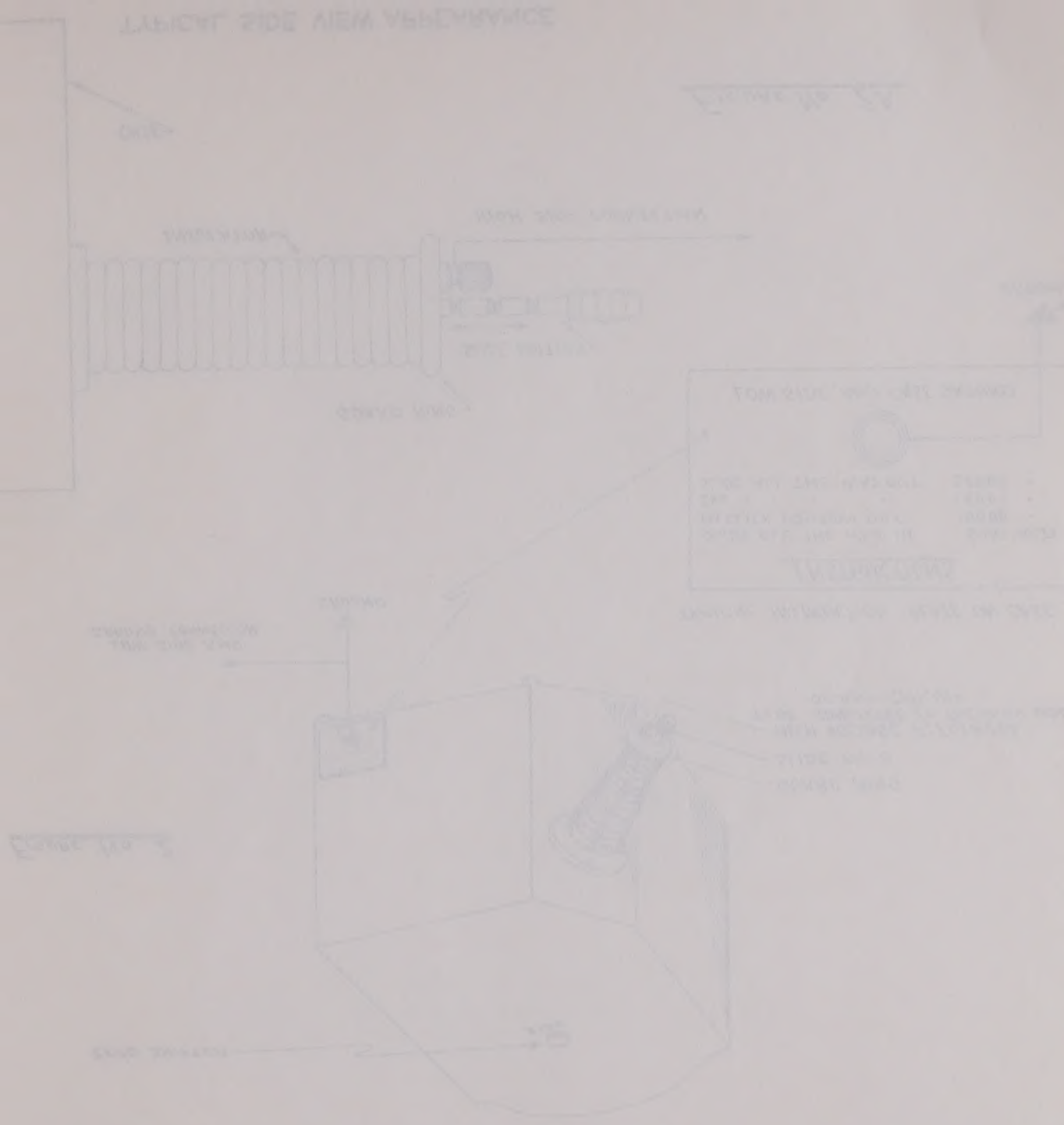


FIGURE No. 2A

TYPICAL SIDE VIEW APPEARANCE



CAUTION

DO NOT TOUCH THE HIGHVOLTAGE BINDING POST OF THE ELECTROSTATIC VOLTMETER WITHOUT FIRST REDUCING THE VOLTAGE TO ZERO. KEEP HIGH VOLTAGE SLIDE ON THE MODEL ESH CLEAN AND FREE FROM MOISTURE. IN CASES OF HIGH ROOM HUNIDITY, TURN OFF VOLTAGE, AND WIPE THE REAR ELECTRODE INSULATION WITH CARBON TETROCHLORIDE.

SENSITIVE RESEARCH Elecrostatic Voltmeters are hand built and hand calibrated. Extreme care has been taken in selecting non-ferrous pivots and natural sapphire, shock-mounted jewel bearings.

The instrument should be used and treated as a precision instrument standard. A small amount of care will bring its return in a life-time of satisfactory instrument operation.

SPECIFICATIONS

MODEL ESH

A.C. & D.C. ELECTROSTATIC VOLTMETERS

VOLTAGE RANGES

ACCURACY - 1%

SCALE LENGTH 6 INCHES

APPROXIMATE CAPACITANCE

RANGE	MAX FREQ	APPROX CAPACITANCE
5000 Volts	6000000 Cycles	8-10 MMF
10000 "	3000000 "	8-10 MMF
20000 "	1800000 "	8-10 MMF
30000 "	140000 "	8-10 MMF
40000 "	100000 "	8-10 MMF
50000 "	94000 "	8-10 MMF
60000 "	85000 "	

MODEL ESD & UNIVERSITY

VOLTAGE RANGES

ACCURACY - 1%

SCALE LENGTH INCHES

APPROXIMATE CAPACITANCE

VOLTAGE RANGE	APPROX CAP. FULL SCALE	MAX. FREQ
120	220 MMF	1.5 Megacyc
150	220 MMF	1.5 "
200	220 MMF	1.2 "
300	220 MMF	1.0 "
500	111 MMF	.65 "
1000	59 MMF	.55 "
1500	30 MMF	.30 "
2000	20 MMF	.25 "
30000	18 MMF	.20 "
4000	18 MMF	.18 "
5000	18 MMF	.17 "
6000	18 MMF	.15 "